INDIAN TEA ASSOCIATION

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TOCKLAI EXPERIMENTAL STATION

Memorandum No. 19

BLACK ROT OF TEA

In North East India

(*CORTICIUM INVISUM*, PETCH)

AND

(*CORTICIUM THEAE*, BERNARD)

By

A. C. TUNSTALL

And

K. C. SARMAH

——:O:——

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Errata

Plate 2—Read Cuttivum instead of Calycinia.

Plate 3—Read Cortinum instead of Corticum.

(Last line)—Read Hept instead of Lept.

Plate 4—Read three instead of fifteen.

Plate 5—Read Corticium instead of Cortinum wherever it occurs.

Read Haustoria instead of Haustori wherever it occurs.

Read (3) Basidia instead of (3) Bosidia.

A. C. TUNSTALL

Ag.I.

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Tea Tree Grafting

BLACK ROT

Corticium invisum, Petch, (formerly referred to as *Hypochnus theae* I. T. A. Quarterly Journal, 1917, page 80) and *Corticium theae*. Bernard.

Corticium invisum, Petch. (Pl. 1)

HISTORY OF THE DISEASE

This leaf disease was probably found to occur on tea in North East India somewhere about 1898 or even earlier. It was then considered to be another form of Grey blight (*Pestalozzia theae*, Saw). Watt & Mann, in their book "The Pests and Blights of the Tea Plant" describe it under Grey blight thus in one place—"It seems possible that a second form of the fungus reproducing by a different method without the intervention of spores may exist. A diseased leaf drops into contact with a healthy leaf below and where they touch become cemented by a tuft of fungus filaments, which are the basis for a new attack." Again in another place "It commences for the most part on one side of a bush, very often on the same side of all the bushes over an affected plot,—a circumstance that may be taken as indicative of the germs having been wind-conveyed. It then may work round or over the bush until every leaf is killed. It appears occasionally to become epidemic, and then as the disease advances the leaves fall off, and lie on the top of the bush, and then the disease will pass from bush to bush until in large plots nearly every bush will be injured". Investigations on Grey blight prove beyond doubt that this latter fungus does not behave in this way. The above descriptions conform with those of Black rot.

Bernard observed a disease of similar nature on tea in Java in 1907, which was named *Hypochnus theae*, and later changed to *Corticium theae*. This fungus also occurs on tea in North East India and behaves in a similar way to *Corticium invisum*, but it is not common. It will be dealt with later in this memorandum.

In North East India, it was recognised for the first time in 1914, on a garden in the Surma Valley and the first serious outbreak recorded as such in Upper Assam took place on a garden in the Lakhimpur district in 1918. It is a wide spread disease and is found to occur in all the tea growing areas.

It is probable that both fungi have been present in North East India for very many years and that the increase in the severity of the damage has been caused by a change in the cultural conditions. Now-a-days well grown tea forms an almost continuous sheet. Each bush is in contact with its neighbours. This is very favourable to the blight which is thus able to grow from bush to bush at points of contact. The increase in shade tends to increase the humidity of the air and thus favours the fungus. The closeness of the shoots on the plucking table of a well grown tea bush also alters the air conditions within the frame-work of branches thus facilitating the growth of the fungus from branch to branch. The elimination of pruning very low at frequent intervals has also played a part by retaining more of the branches which are capable of carrying over infection from season to season. It is not surprising therefore that Black rot has been causing more trouble in recent years. Of course, the general improvement in the efficiency of the bushes much more than compensates for the increase in susceptibility to damage from Black rot.

The name Black rot was originally given to the fungus in Ceylon. It has also been adopted in North East India. Both the species of *Corticium*, viz., *Corticium invisum* and *Corticium theae* produce the same effect on the tea bush and sometimes they occur together. Hence in order to avoid confusion both these species have been included under the same heading—Black rot.

During very wet weather the diseased patches on the leaves often assume a black colour. The young diseased leaves, in particular, become black, rotten and slimy. The disease appears on the leaves, from May to October in the plains and about August to October in the hills districts, as a number of small spots of irregular shape. These are sometimes accompanied by groups of still smaller dots, blackish brown or greyish white on

the upper surface. These spots gradually enlarge, run together and finally form large patches, dotted at the edge where the small spots remain farther away. The larger patches sometimes appear to resemble those caused by Brown blight *(Glomerella cingulata)* and Grey blight *(Pestalozzia theae)* but they differ from these in many details. The colour of Black rot patches, on the upper surface of the leaves, is patchy and is usually a mixture of brown, yellow-brown or chocolate-brown mottled with greyish-white spots and smears, the latter especially along the veins. The margin is very irregular and is not well defined as in Brown and Grey blights. It appears to be slighly raised, giving the diseased patch a little sunken appearance. Zonated markings are also absent in Black rot. Of course it is not unusual for Brown and Grey blights to occur on Black rot affected patches but even then the characteristic features of the latter predominate. On the under surface of the leaves the colour of the diseased area is more even. It is either dull brown, pale chocolate brown or dull grey. The raised appearance of the margin of the diseased area, as on the upper surface, is usually present. On light coloured, thin leaves the spots are frequently lighter in colour with a somewhat dark margin.

As the fungus spreads from the stem to the under surface of the leaves via the leaf stalk one would expect the diseased patches on the leaves to occur near the base but it is not so. The patches may form on any portion of the leaf.

The mycelium of the fungus (Pl. 5 - fig. 5) is very fine and quite colourless at first, turning slightly yellowish with age. In mass it is white, pinkish white or cream coloured. Under ordinary conditions the mycelial threads are invisible to the naked eye -hence the name *Corticium invisum.* Formerly the fungus was thought to be confined only to the green portions of the tea plant but subsequent observations have shown that it can spread over all the parts of the tea bush above ground. It only causes damage to the green portions.

APPEARANCE OF A SEVERELY AFFECTED TEA PLANT

The diseased leaves die after a time but all of them do not fall off. Some remain hanging on the stems by means of small pinkish white or

white to cream cushions of mycelium formed at the angle of the leaf with the stem (Pl. 1—fig. 1). Others remain attached to other leaves and stems (Pl. 1—fig. 2) held together by such cushions or by thin films of delicate white mycelium at points of contact. These are easily seen either by holding the leaves against the light and slowly pulling them apart or by means of a pocket lens. The general appearance of a tea bush attacked by Black rot is similar to one severely affected by Brown and Grey blights with the only exception of dangling leaves, or to that produced by Thread blight without the presence of distinct white cords of mycelium so characteristic of the latter. Black rot also spreads much more rapidly than Thread blight.

LIFE-HISTORY AND DISSEMINATION OF THE FUNGUS

During the rainy season the fungus produces its spores (Pl. 5 - fig 8), on the under surface of the apparently healthy, mature leaves on a diseased bush. The fructifications appear as white, powdery patches—similar to a damp surface lightly dusted with chalk powder. The powdery appearance is due to the production of numerous club-shaped projections (basidia) each carrying four spores at the end of four small horns (sterigmata) (Pl.5 - fig 7). The spores are borne to other bushes by wind, hands and clothing of workers, cattle etc. Diseased bits of material are also distributed in a similar way. It also spreads by contact from bush to bush. Once the fungus gets its hold on a tea bush it is capable of living on it for years. Besides the spores, it produces a resting stage which carries the fungus through the winter season. This consists of small, microscopic lumps, formed of specially designed groups of fungus cells (known as sclerotia) embedded in the dead primary bark of the stems (Pls. 2 & 3) and also in the cracks and crevices on the lower branches. The sclerotia are produced in profusion at the beginning of the cold season. Although the majority of them are removed in the course of pruning, some are always left below the pruning level. Early in the rainy season mycelial filaments grow out from these sclerotia and extend along the stems to the undersides of the leaves.

PLATE 1 —*Corticium invisum*, Petch ; (1) Dead leaf hanging on the stem ; (2) Diseased leaves stuck to each other.

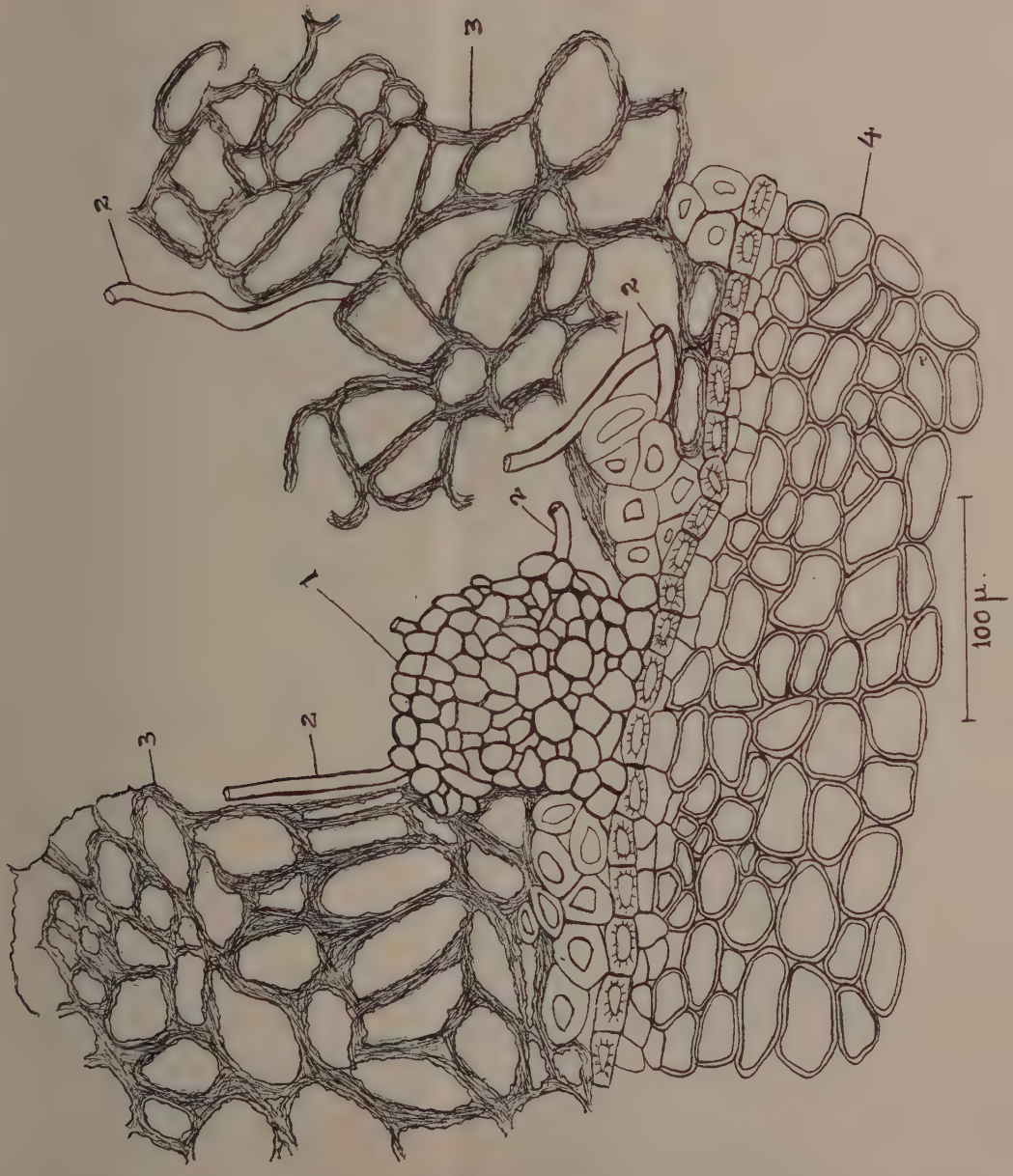


PLATE 2--Cross section of a tea stem showing a Sclerotium of Corticuim invisum, Petch ; (1) Sclerotium, (2) Hyphae, (3) Primary cortex (dead tissue), (4) Phloem (living tissue).

PLATE 3—Longitudinal section of the dead primary cortex of a tea stem showing sclerotia of *Corticium invisum*, Petch ; (1) Hyphae, (2) Sclerotial cells filled with granular contents, (3) Dead Lost tissue.

PLATE 4—*Corticium theae*, Bernard ; (1) Mycelial cords on the stem ; (2) Diseased leaves hanging on the stem.

The sclerotia in prunings, collected in the middle of December and buried under three inches of soil, have been found to remain viable for six months and to be capable of reinfecting bushes in the following May.

PENETRATION OF THE PLANT TISSUES

The fungus mycelium appears to be wholly external. It has never been found to penetrate the leaf tissues. It penetrates the primary bark on the stems after it ceases to function (the primary bark, after a time cracks and peels off). The fungus produces on the green portions of the plant numerous suckers, which, are root-like bunches known as haustoria (Pl. 5—fig 6). It is believed that it derives its nourishment from the host plant through these haustoria. But whether they serve as anchors or food sucking devices for the fungus is not definitely known.

HOSTS OTHER THAN TEA

Corticium invisum has been found to attack other plants besides tea. Arhar *(Cajanus indicus)*, Boga medeloa *(Tephrosia candida)*, Tung *(Aleuritis spp.,)* and weeds and grasses growing under diseased tea bushes are so far known to be susceptible. It is probable that the fungus is capable of attacking many other plants.

Corticium theae BERNARD (Pl. 4)

The other species of *Corticium (Corticium theae)* was first observed on tea in Java where, although it occurred on fairly large numbers of bushes on some occasions, the damage was not considered to be very serious. In North East India it sometimes occurs on the same bushes affected by *Corticium invisum*. It has only been found, by itself, in a limited number of cases, hence there has been no opportunity of estimating the amount of damage the fungus is capable of doing.

The fungus grows along the stems upwards forming thick cords up to about 3 m. m. broad (Pl.4 —fig 1). These cords are not readily noticed as they are of the same colour as the bark On the upper portion however, the colour of the stems being either green or reddish brown, the creamy or whitish-brown cords become readily visible. They

have not been observed on more than 3 years old branches. The cords on drying, turn brown after a time and thus become quite prominent. They branch and anastomose at frequent intervals and attach themselves to the stem by means of suckers haustoria (Pl. 5—fig. 2). Mycelial branch-filaments do not appear to penetrate into the living stem tissues but the writers have observed damage to the tissues of the tea stems actually beneath the mycelial cords The cords spread along the leaf stalks to the under surfaces of the leaves where they spread out forming a net work.

The diseased patches on the leaves differ from those caused by *Corticium invisum*. Here the patches are larger, usually covering about half, and sometimes the entire area of the leaf. The colour on the upper surface is a mixture of yellowish brown and greyish white smears and the margin of the diseased patch is a little less irregular and is more prominent than in case of *Corticium invisum*. The under surface is more evenly coloured with greyish white and the sunken appearance of the diseased patch as in *Corticium invisum* is not noticeable.

Fructifications of the fungus (Pl. 5—figs. 3 & 4) appear, in the same way as in *Corticium invisum*, as white powdery patches on the under surface of apparently healthy, green leaves. The diseased leaves are attached to the branches and other leaves by the mycelium just as in Thread blight (Pl. 4—fig. 2).

CONDITIONS FAVOURABLE FOR THE DISEASE

Conditions which most favour the damage from Black rot are heat combined with high humidity. It seems to thrive best and persist for years in badly ventilated places, such as low areas between two hills, low corners more or less surrounded by jungle etc., where the air in the rainy season is hot, moist and still.

On old infected bushes, the disease starts growth on the lower branches during the early rains and it appears on the upper portion of the bushes sometimes from May onwards and become severe towards the end of July. New infections, as a rule, occur about the middle of the rainy season. Well grown tea in which the bushes are touching is more likely to be attacked than poorer areas as the fungus can readily grow

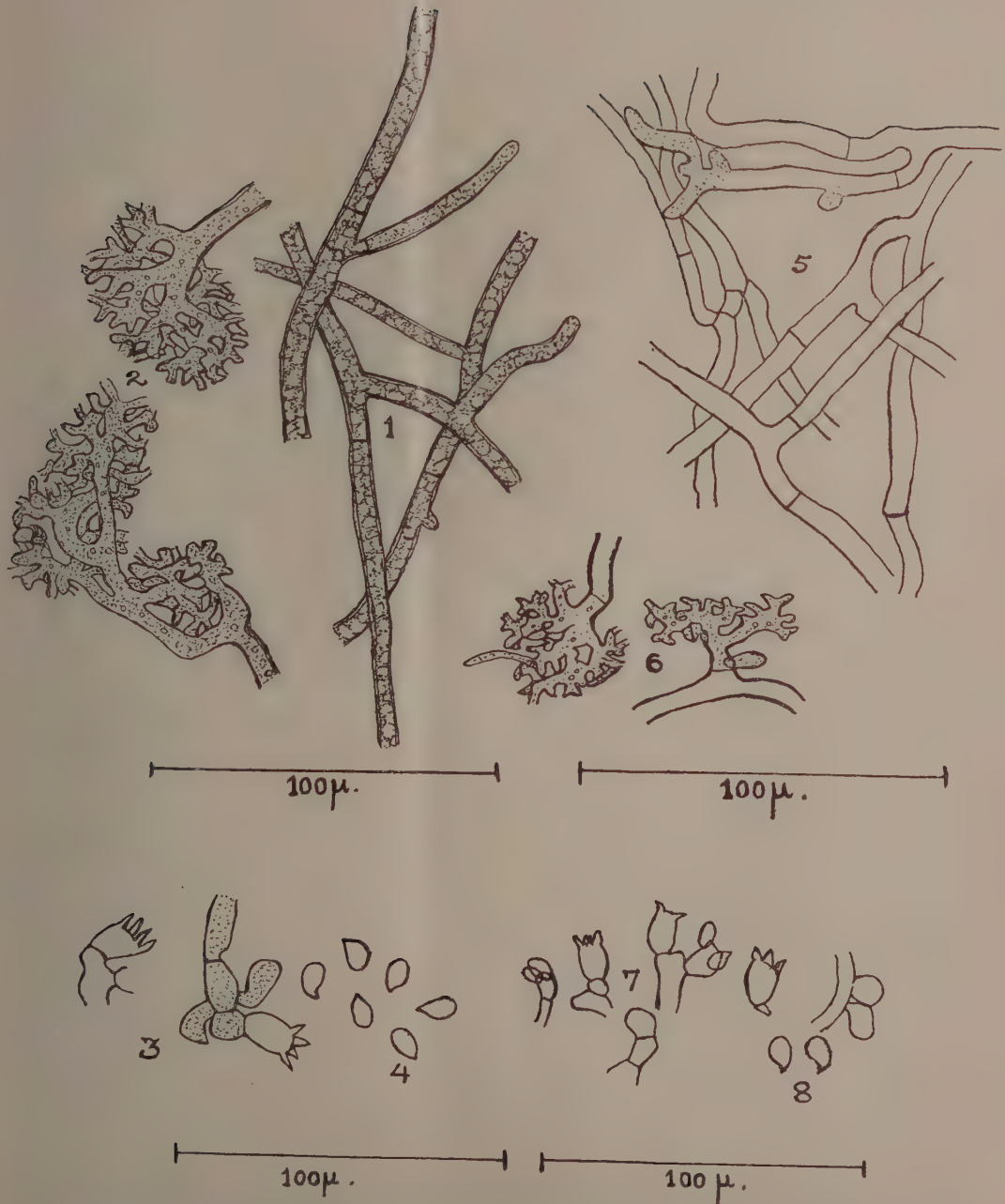


PLATE 5—Figs 1-4, *Corticuim theae* Bernard, (1) Hyphae, (2) Hanstoria, (3) Bosidia and (4) Basidiospores, Figs 5-8, *Corticuim invisum*, Petch ; (5) Hyphae, (6) Hanstoria, (7) Basidia and (8) Basidiospores.

from one bush to the next at points of contact. Given suitable conditions it may spread with alarming rapidity but on good tea the loss caused by the disease is not apparent for a year or two as healthy bushes are able to lose a certain amount of leaf without serious effects. In time however, even the most vigorous bushes suffer and go back. Undue reduction in leaf area, year after year, causes debility and the crop falls seriously. The loss is more quickly noticeable on areas where the tea is already in poor condition.

EFFECT OF BLACK ROT ON YIELD OF LEAF

The reduction of the effective leaf area prevents the plant from absorbing its full requirements of energy and eventually the production of new leaf is hindered by the lack of the energy required for its growth. The effects of a disease that reduces the effective leaf area but does not attack the plucking shoots is not immediately apparent. In the course of a season a bush badly infected by Black rot produces about half its normal crop. This is shown by the percentage reduction in crop on a plot being roughly half the percentage of badly infected bushes. Thus if 10% of the total numbers of bushes are badly attacked the loss will be approximately 5% of the plucked leaf. In terms of crop per acre it is obvious that the loss will be much greater on high yielding than on low yielding tea areas.

TREATMENT

The Black rot fungus is distributed in two ways—by growing from bush to bush at points of contact and by means of airborne spores. It is also able to survive the dry season as sclerotia within the dried up primary cortex on the branches. It is not confined to tea only. Taking all these things into account it is obvious that complete eradication of the parasite is very improbable. It is therefore desirable to find out whether there are any cultural modifications likely to mitigate the damage caused by the disease. With this object in view one of the writers made repeated visits to many of the tea gardens concerned.

The most severe attacks are invariably on well grown tea bushes in close contact with each other, thus facilitating the spread of the fungus from bush to bush. Of such tea areas those in open places where there is free ventilation are not damaged so severely as areas shut in by jungle or

hills. The hot steamy atmosphere of the latter areas is obvious during the growing season. Where it was possible to improve the ventilation by cutting back jungle or opening up a wind funnel through the jungle the damage on the areas previously shut in was considerably reduced.

MANURING

Advantage was taken of various manurial experiments to ascertain the effect of manuring on the incidence of Black rot. There was none apparent.

PRUNING

The effect of pruning was considerable. The number of infected bushes on unpruned and lightly skiffed tea increases more rapidly than on light pruned, which in turn is more favourable to the disease than cleaned out tea. Cutting back removes most of the infection. Serious reinfection does not usually occur on cut back areas for some years after the cutting back.

An experiment proved that the burial of prunings compared with leaving them on the ground was not followed by any reduction in the number of bushes infected in the following year. Advantage may be taken of the effect of cutting back by postponing active treatment on areas about to be cut back until after that operation. Cleaning out pruning is also desirable as it certainly delays the onset of the disease in the following season.

EFFECT OF LEAVING BUSHES UNPLUCKED

It was noticed by many planters that the blight apparently disappeared during a period when a section was left unplucked. Closer examination showed that the fungus still remained active on the unplucked bushes but in the absence of young leaves its effects were not so noticeable. When normal plucking was resumed on the sections concerned the blight was as bad as before the resting period.

DISSEMINATION OF THE FUNGUS

Observations of the spread of the disease on individual areas showed that spores did not usually play such an important part as the growth of fungus mycelium from bush to bush. Occasionally however wind borne spores do cause a rapid extension of infection. Fortunately such cases are uncommon.

The above observations do not warrant any assumption that Black rot can be effectively controlled indirectly by modifications of normal cultural methods. It is necessary to make a direct attack on the fungus wherever it is causing serious damage.

REMOVAL OF DISEASED MATERIAL

The cutting out of all the diseased material and its removal is of course impractical when the percentage of infected bushes is high. The pulling off of masses of diseased leaves from infected bushes does however tend to reduce infection even when the infected material is left unburied under the bushes.

SPRAYING

The only practical means we have of directly attacking a fungus disease of the leaves is by applying fungicides. In the present state of our knowledge there are only two kinds of fungicide available - compounds of sulphur and compounds of copper. Experiments indicate that copper compounds are more effective than sulphur ones against fungi of the type of *Corticium (Basidiomycetes)*. Burgundy mixture and Lime sulphur solution were used in our field experiments as the ingredients of both these fluids are readily available. In later experiments a proprietary form of copper fungicide called Perenox was also used. A few experiments were also made with copper compounds in the form of dry dusts.

TREATMENT IN THE GROWING SEASON

As the disease, under suitable conditions, is capable of spreading with extraordinary rapidity, remedial measures should be adopted at the earliest opportunity.

It is however a matter of some difficulty to recognise Black rot in its early stages. Other common leaf diseases such as Brown and Grey blights may be confused with it. These blights, however, do not as a rule attack many bushes during the first flush. It will not involve any serious increase in work if all bushes bearing any disease on the young growth be assumed to be attacked by Black rot. In the second flush some discrimination is possible and by the time the third flush is on the bushes the Black rot may be recognised without difficulty. The diseased bushes should be treated as follows.

All debris should be pulled out of the frames and dropped on the ground immediately beneath the diseased bushes. The bushes concerned should be thoroughly sprayed either with 1% Burgundy mixture or 0.5% Perenox, taking care to wet the undersides of all the leaves with the spray fluid.

To do this work properly it is necessary to organise it carefully. It is of very little use to send out coolies to look for the diseased bushes. It is necessary to obtain the co-operation of the pluckers. The plucking sirdars should be provided with a known number of flags. The pluckers must be induced to indicate the bushes showing signs of disease on the young growth to the sirdars who will flag them.

The number of bushes flagged in each section may be estimated by counting the remaining unused flags. This should be recorded at the time the leaf is weighed in.

The following morning a special gang of coolies should be sent out with sprayers and spraying material to treat all the bushes flagged on the previous day. (The approximate amount of spray fluid required for spraying a bush of average size thoroughly is 1½ lbs.). After treatment the paper may be removed from the flags, leaving the sticks to indicate the bushes which have been treated. The number of bushes treated in each section and the materials used each day should also be recorded. In this way a continuous check on the work done may be maintained throughout the season. If such records are not kept it is unlikely that the work will be done satisfactorily. Good supervision is essential for the success of such operations and in the absence of records it is impossible to see where and when extra attention is desirable. The treatment of diseased bushes should be continued, without any remission, throughout the growing season. Sometimes it may be necessary to spray the same bushes a second or even a third time.

It is probable that inspite of the above efforts the disease will become prevalent on some sections. If circumstances permit such sections or portions of sections should be omitted from plucking or if this is undesirable they should be plucked by a separate gang and matters arranged, as far as practicable so that the passage of coolies from infected tea to uninfected tea be avoided. If the very bad areas are kept in the plucking round they should be sprayed with Lime sulphur solution (1 part 8° Beaume with 3 parts water) by a separate gang of coolies so that the following up of the disease on other areas may not be interfered with. Lime sulphur is suggested for this purpose on account of its cheapness. This becomes an important consideration

when large areas are involved. It should however be emphasized that while Lime sulphur sprays are excellent palliatives, they are not so effective as copper mixtures in preventing a revival of the fungus.

No cold weather treatment has been found to be efficient enough to eradicate the disease without doing some damage to the bushes. Painting the bushes thoroughly, during the cold season, with fungicides mixed with oils such as kerosine, fuel oil etc., kills the fungus but such applications when sufficiently strong retard the development of the buds to a great extent and thus not infrequently damage the bushes concerned.

When a diseased section is going to be cut back there is no need to treat the Black rot in the previous season as most of the disease will be removed by the pruning Immediately after pruning the whole of the bark should be painted with whitewash containing, in addition to the lime, 1 lb. of caustic soda in each 10 gallons. This will serve the double purpose of protecting the newly exposed bark from sunscorch and also have a deterrent effect on the development of any Black rot fungus that may be in a resting stage within the bark.

Whatever be done in the dry season it is certain that the disease will survive on a few bushes. If these bushes are not treated promptly whenever the Black rot reappears it will spread again in the course of the following season and the condition at the end will probably be just as bad as it was before. It is particularly important to reduce the numbers of centres of infection in the early part of the season before the spores are produced freely.

EFFECT OF SPRAYING ON PLANT GROWTH

It is a well established fact that the application of any sort of fluid to the undersides of the leaves of a plant is followed by a temporary check to growth. This however is compensated for later by an acceleration in growth. If the spraying is done at a time when growth is normally slow e.g., between flushes, the increase may take place during the following natural acceleration. As the decrease or increase is approximately the same percentage of the growth being made during the period

concerned, should the decrease caused by the spraying occur during a natural lull there may be an aggregate gain in crop during the subsequent acceleration in growth. Under present conditions however this is only of academic interest but if the methods of spraying are so improved that large areas may be sprayed with great rapidity advantage may be taken of this observation.

EFFECT OF SPRAY CHEMICALS ON PLANT GROWTH

Frequent use of copper fungicides tend to have a stunting effect on tea plants. This is not noticeable on plucking bushes but it is very obvious in nurseries that have been sprayed with 1% Burgundy mixture or 0.5% Perenox a number of times at short intervals. One or two applications cause no visible effect but more than two may be detrimental. It is therefore recommended that when it is found necessary to protect a nursery for a long period the copper fungicide should be alternated with Lime sulphur solution.

APPENDIX

SUMMARY OF RESULTS OF EXPERIMENTS

Spraying with Winter Washes during the dormant period was of doubtful value. In one experiment only an useful result was obtained but in others no effect at all was observed. May seems to be the earliest time during which spraying of all the bushes with 1% Burgundy mixture has a real effect. By that time the bushes are in full leaf. Lime sulphur solution has little prophylactic effect.

During the plucking season better results are obtained by treating the infected bushes as they are observed.

1% Burgundy mixture and 0. 5% Perenox applied to infected bushes only are both effective fungicides for the treatment of Black rot in the plucking season. No advantage was obtained from the use of rosin adhesive. Mixtures stronger than 1% Burgundy mixture or 0. 5% Perenox did not increase efficiency sufficiently to warrant the extra cost. Both these fluids are effective against the Black rot fungus. The difficulty lies in the application.

Lime sulphur solution even at concentration of 1 part 33° Beaume concentrate with 4 parts of water, while reducing the loss in crop by checking the fungus, did not kill it.

SOME EXPERIMENTS ON TREATMENT

GENERAL PLAN

All the experiments were carried out on plots of 100 bushes usually 10 rows by 10 rows. The plots were arranged in Latin squares i. e. in columns and rows each containing all the treatments.

A specially designed record book was supplied to the managers. In this the yield of each plot and the position of each infected bush was noted at each plucking round. It was not practicable to record the intensity of the infection on each bush and any bush bearing any traces of

infection on the young leaf was entered in the record book as an infected bush.

The applications were made by the garden staff with the machines in normal use on the gardens concerned. The record books were sent to Tocklai at the conclusion of each season's work. Great credit is due to the managers concerned for their care and efficiency in supervising the work.

COLD WEATHER TREATMENT

The experiments on the application of fungicides during the cold weather showed no results. It was however observed that the numbers of diseased bushes in the year following cleaning out pruning were less than those on plots which had been skiffed, or light pruned in the ordinary way. It was also observed that cutting back below the red wood removed most of the damage. No advantage followed the burial of prunings. Laboratory experiments showed that the fungus can survive in buried prunings for a whole season.

The curative effect of the treatment on a seasonal disease such as Black rot cannot be estimated with certainty in the current year. It is desirable to wait and see how many of the treated bushes show signs of infection in the following season. Some of these may of course have been reinfected but our observations on a number of gardens show that the spread of new infection is usually very slow. The sudden onslaught of the disease during the rainy season is for the most part due to the revival of the fungus on bushes already infected and not to new infection.

THE EFFECT OF PULLING OFF CLUSTERS OF DISEASED LEAVES

In the following table the numbers of bushes found to be infected in 1939 and the numbers of those bushes again found to be infected in 1940 are given. The experiment was carried out on a garden in Assam.

As the treatment has obviously had some effect on the number of bushes found to be infected during 1939, the 1940 figures have been adjusted by covariance with the 1939 ones to see what might have happened if the 1939 figures for all series were equal.

PERCENTAGE OF INFECTED BUSHES

	1939	1940 Adjusted on 1939 figures.
A. Diseased leaf pulled off and carried away	99	74
B. Diseased leaf pulled off and buried near bushes	98	79
C. As A followed by 1% Burgundy mixture	93	64
D. As A followed by 0.25% Perenox	93	67
E. 0.25% Perenox only	100	93
Sign. diff. P = .05	5	17

The removal of the diseased leaf and spraying without such removal had no effect on the numbers of diseased bushes in the first year (1939). The plots on which removal of diseased leaf was followed by spraying had significantly fewer diseased bushes than all the other series. There was no difference between the effect of the 1% Burgundy mixture and 0.25% Perenox on these plots.

In the second year (1940) the effect of the removal of diseased leaf shows up and the series on which diseased leaf was left on the bushes is obviously the worst in spite of spraying with 0.25% Perenox. Again the combination of removal of diseased leaves and spraying is more satisfactory than either spraying or diseased leaf removal alone. There is again no difference in the efficiency of the two spray fluids used. In the adjusted figures the differences between the various series are barely significant. This suggests that the effect of the two successive years of treatment is cumulative. There seems to be no significant advantage in carrying away the diseased leaves after their removal from the bushes.

TIME OF APPLICATION

The application of fungicides is a costly and difficult business and the most convenient time to apply them is during the dormant period when the bushes bear the least amount of leaf and labour is more readily available. In the case of Black rot however it is impossible to distinguish infected bushes at that time and it is then necessary to spray all the bushes in the areas concerned. It was found that even 4% Burgundy mixture applied to

all the bushes after pruning had no appreciable effect on the incidence of the disease in the following season.

The following are the results of an experiment on a garden in Upper Assam.

5 series of plots, arranged in a Latin square, each containing 5 × 100 bushes—roughly 1/5th of an acre—were sprayed with the following fungicides immediately after pruning in 1935.

A. 4% Burgundy mixture with rosin adhesive
B. „ „ „ without „
C. 1% „ „ with „
D. Lime sulphur solution 8° Beaume 1 part with water 2 parts
E. No treatment

The bushes attacked before pruning and those on which infection appeared at any time during the following season up to the 3rd week of September were recorded.

Series	Percentage of bushes diseased before pruning	Percentage of bushes on which disease was found at any time up to September.	
		Actual	Adjusted to equal numbers of previously diseased bushes
A.	72	64	68
B.	82	68	67
C.	78	70	70
D.	85	77	74
E.	78	72	72

There was no significant difference.

Further experiments were made and it was found that spraying with either Burgundy mixture or Lime sulphur solution before the end of April was ineffective no matter what concentrations were used.

A further series of field experiments were carried out to ascertain the effectiveness of spraying during the plucking season.

On experimental plots on a Sylhet garden the treatments and the percentage of infection at the end of June are given in the following table.

Series	Treatment	Percentage of infection	
A.	1% Burgundy mixture with adhesive } to all bushes early in May	5.0	The whole area on this garden had been sprayed with Lime sulphur immediately after pruning.
B.	1% Burgundy mixture without adhesive }	1.6	
C.	Check	28.0	
D.	As C with Lime sulphur again to all bushes early in May	34.8	
E.	Check	30.0	
Sign. diff. P = .05		17.0	

It is obvious from the above that the Burgundy mixture with or without adhesive was much more efficient as a preventive than the Lime sulphur solution.

Some more figures were received from this garden at the end of July. The chart did not indicate whether any of the bushes found to be infected in June had recovered. The figures for the new infections expressed as a percentage of the bushes uninfected at the June count gave the following results.

Series.	Average percentage per plot.
A.	9.4
B.	9.8
C.	23.8
D.	31.8
E.	22.0
Sign. diff.	18.0

If the total infection to the end of July is expressed as a percentage of the total bushes in each plot, the following figures are obtained.

Series.	Average percentage per plot.
A	14.0
B	10.8
C	45.6
D	47.6
E	44.6
Sign diff	20.4

It will be clearly seen that at the end of July i.e. three months after spraying there is a difference of over 30% between the plots sprayed with Burgundy mixture and the remainder. It must be clearly understood that these figures apply only to the prevention of infection. They contain no data regarding the effect of the treatment on recovery. It is obvious that the Lime sulphur solution applied to the D series at the same time as the Burgundy mixture was applied to the A and B plots, has afforded no protection against infection. The addition of rosin adhesive to the Burgundy mixture has made no difference.

On a garden in Cachar the treatments were applied in the following way.

Series. Spraying applied to all bushes.

A. 1% Burgundy mixture with rosin adhesive on May 6th and July 10th.

B. 1% Burgundy mixture without rosin adhesive on May 6th and July 10th.

C. Lime sulphur solution on February 26th and 1% Burgundy mixtnre with rosin adhesive on July 10th.

D. Lime sulphur solution on May 8th and July 10th.

E. No treatment.

Before pruning all the bushes on the plots selected for the experiment were attacked. At the end of April the position was as follows.

Series. A. 38% infected
B. 29% ,,
C. 32% ,,
D. 23% ,,
E. 25% ,,

Series C sprayed with Lime sulphur two months earlier, seems to have rather more Black rot than the others except A. The same scheme of experiments was used as in the garden first mentioned.

At the end of May more bushes were attacked and at first sight it would appear that all series were equally bad. A count of the infected bushes however showed that the percentages shown below escaped infection.

Series A. 9.0% escapes
B. 18.5% „
C. 11.0% „
D. 8.0% „
E. 4.4% „
No significance.

Assuming that the percentage of bushes attacked at the end of April is a measure of the susceptibility of the various plots to the Black rot the above figures may be adjusted by the covariance method to what they would be if conditions were equal. The results of this operation are as follows.

Series A. 13.2% escapes
B. 18.4% „
C. 10.8% „
D. 6.8% „
E. 1.8% „
Sign. diff. 17.4 ($P = .05$).

These figures are suggestive of effect but the differences are not significant for $p = .05$. This means that there is less than a 20 to 1 chance against the differences being due to accident.

As there was considerable irregularity in the tea bushes on the plots due to drains etc., it is possible to obtain more useful figures by finding the percentage of bushes becoming infected during May of those uninfected bushes in actual contact with bushes infected in April.

Working in this way the percentage of bushes, adjoining infected ones, which escaped infection is as follows.

Series A. 14% escapes.
B 33% „
C 16% „
D 12% „
E 4% „
Sign. diff. 16

Again assuming that the percentage of infection at the end of April is a measure of the degree of susceptibility of the various plots and adjusting the figures for the escapes by covariance taking the percentage of infection in April as the preliminary the following is obtained.

Series A. 11.4% adjusted percentage of escapes

B. 32.4% „ „

C. 15.4% „ „

D. 14.4% „ „

E. 5.4% „ „

Sign. diff. 7.4

In this case the significance is more than doubled. This strengthens the assumption that the percentage infection at the end of April was a measure of susceptibility.

From the above figures it would appear that series B, sprayed early in May with Burgundy mixture had significantly more escapes than any of the other series. Series E, which was untreated, had significantly fewer escapes than all other series except A. The poor results from Burgundy mixture with rosin adhesive was due to the type of sprayers used. The application of the somewhat viscid fluid required a higher pressure than the sprayers could maintain. There was no difference between the series sprayed with Lime sulphur in the cold weather and that sprayed in the beginning of May.

The principal object of the treatment is to reduce permanently the number of bushes infected. As the disease is no longer apparent at the end of the growing season the effect cannot be judged until the following season. The climatic conditions however differ considerably in successive seasons and in some cases the natural reduction in the amount of the disease present is sufficient to mask the effects of the previous season's treatment. On one experimental area the natural reduction due to climatic conditions unfavourable to the fungus was as much as 65%.

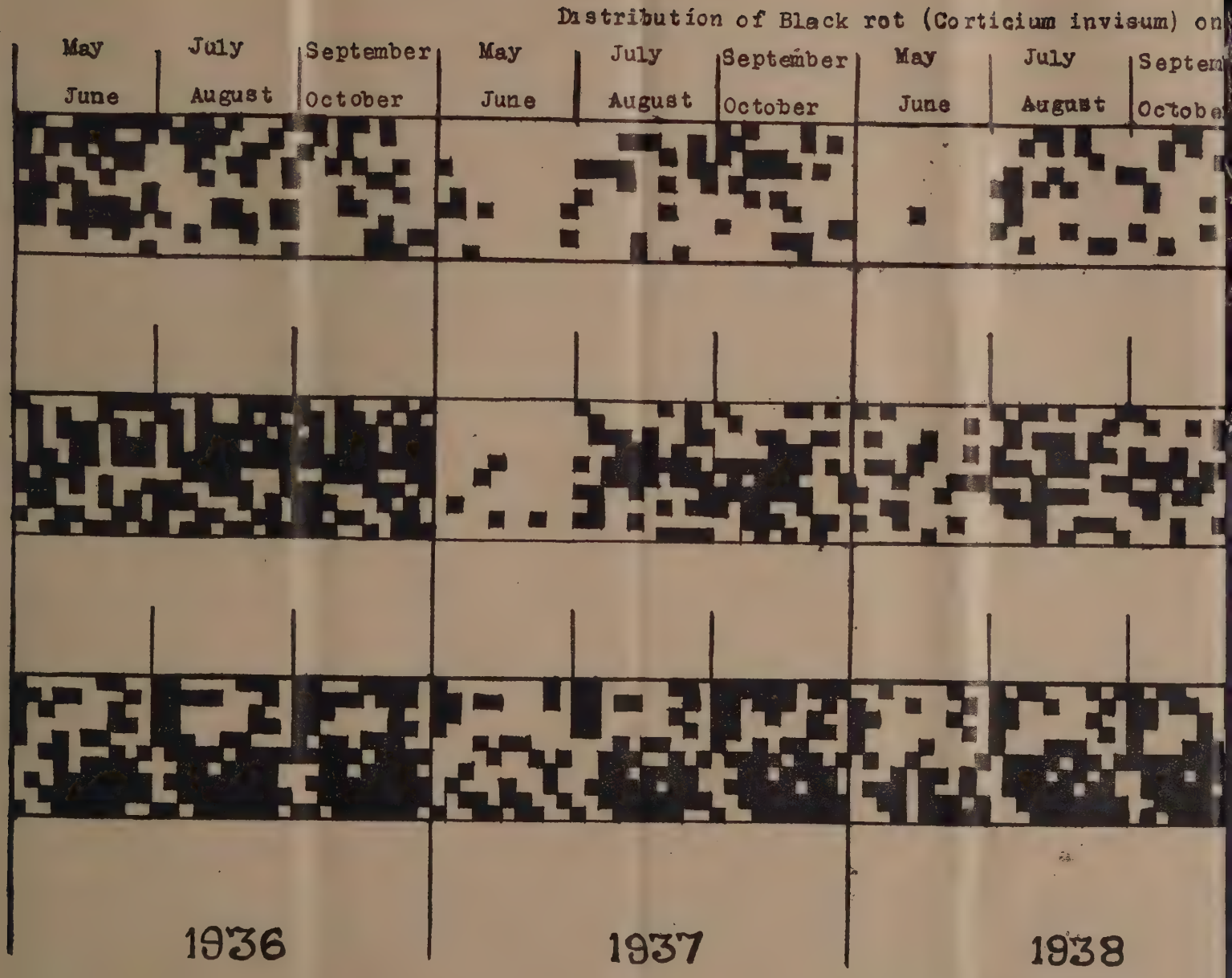
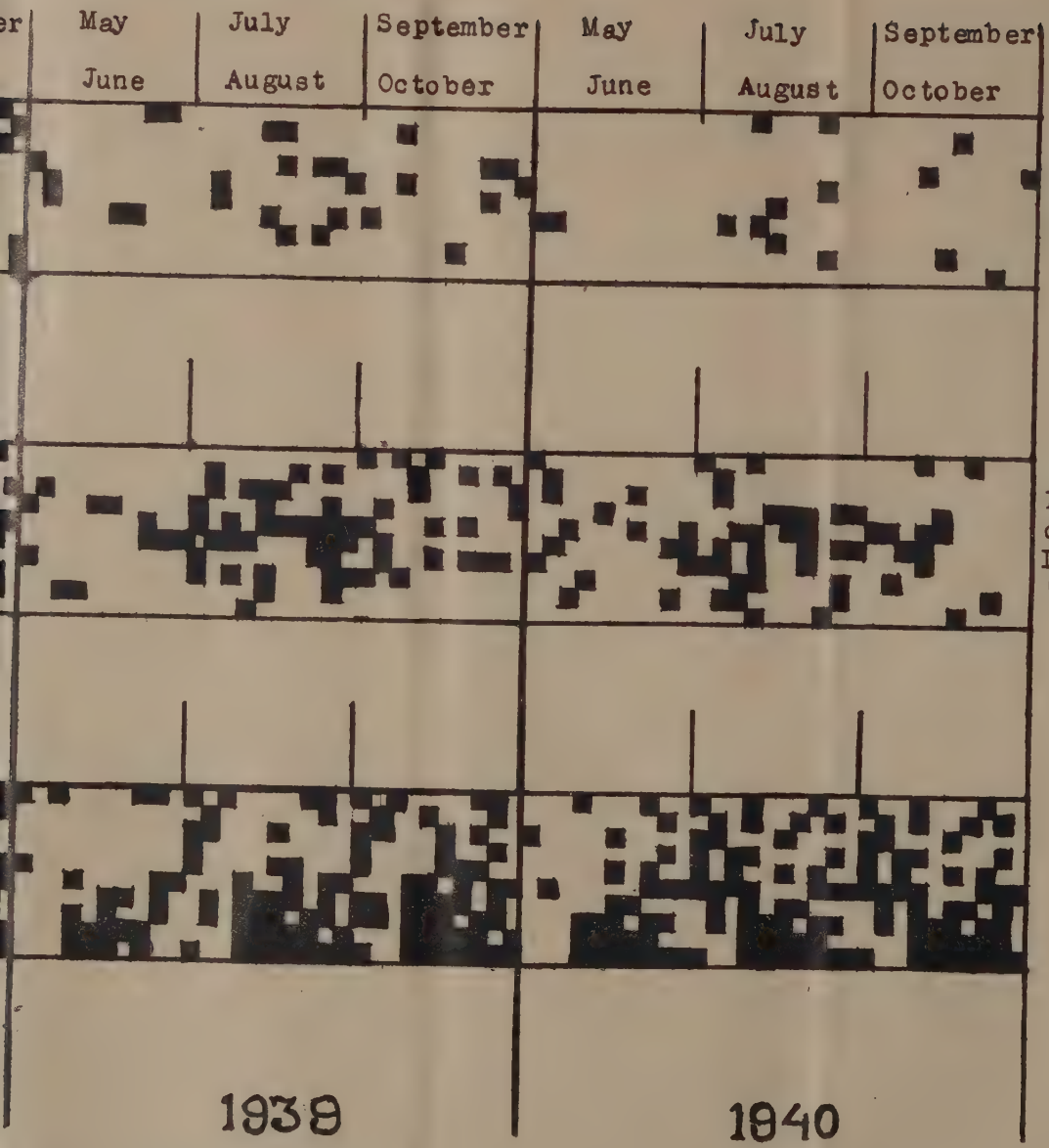


PLATE 6—Effect of spraying on Black Rot. Bla

three experimental plots.



squares indicate diseased bushes.

These fluctuations are not so great on badly ventilated areas and most of the experimental plots were arranged in such areas. This introduced another difficulty. As the climatic conditions were so favourable to the fungus, reinfection of the treated areas from the neighbouring untreated ones was considerable. The efficiency of the treatments was thus less than that which might be expected when the whole of a section is under treatment.

In some experiments the pressure in the spraying machines available was insufficient to ensure a good film of fungicide when rosin adhesive was used as the mixture tended to clog the nozzles frequently. It is doubtful whether any spreader or adhesive is required when spraying tea with Burgundy mixture.

THE SEASONAL PROGRESS OF THE DISEASE

The seasonal progress of the disease is illustrated in the diagrams which show the position of the infected bushes in the early, mid season and late periods in each of four successive years (Pl.6). The plots in question were on a garden in Assam. As will be seen from the untreated plot the area was very heavily infected yet in spite of the small size of the plots and their proximity to untreated areas the effect of the application of the spray fluid to infected bushes whenever they were observed is very marked.

The experiment on the treatment of Black rot on this garden was continued for five successive years and the results obtained have been of great value.

TREATING INFECTED BUSHES ONLY WHENEVER OBSERVED

The following treatments were applied to all diseased bushes whenever they were observed throughout the growing season. Undiseased bushes were not treated.

A 4% Burgundy mixture with rosin adhesive.
B 4% Burgundy mixture without rosin adhesive.
C 1% Burgundy mixture with rosin adhesive
D Lime sulphur solution (30° Beaume concentrate) 1 in 5.
E No treatment.

Just before spraying any masses of diseased leaves were pulled off and dropped on the ground under the bush concerned. This was purely to facilitate the spraying.

The results of the observations are given in the following table.

Number of bushes infected at any time during the respective years as percentage of total number of bushes.

Series	1936	1937	1938	1939	1940	Average percentage calculated on total numbers
A	68	41	32	18	21	35
B	64	41	36	26	28	40
C	70	44	44	22	20	40
D	77	58	56	34	31	51
E	72	68	67	47	38	58

Sign. diff. annual treatment totals (P = .05) 10%

AVERAGE DURATION OF INFECTION IN WEEKS

Series	1936	1937	1938	1939	1940
A	2 65	2.61	3.44	2.77	2.99
B	2.89	2.50	2.66	2.49	3.02
C	3.77	2.89	3.38	2.64	3.07
D	12.56	3.65	5.45	3.52	3.34
E	20.26	16.05	14.88	14.90	14.22

YIELDS AS PERCENTAGE OF CHECK

Series	1936	1937	1938	1939
A	108	109	110	111
B	109	112	107	110
C	107	110	111	109
D	104	112	108	109
E	100	100	100	100

In 1940 the intensity of the infection on the individual bushes was very low and the figures for total infection did not show a significant correlation with crop as they did in previous years, when the intensity of the attack was greater. There is no appreciable difference in the yield of the various series during 1940. The 1939 figures continue to show a significant negative correlation between the degree of infection and

yield while those for 1940 fail to do so. For purposes of calculating the advantage in crop obtained by controlling the Black rot the figures for 1940 have been excluded. It was noticed that in 1940 the intensity of the infection was much lower than usual in all the tea districts of North East India.

THE PERCENTAGE OF DISEASED BUSHES WHICH SHOWED NO SIGNS OF THE DISEASE IN THE FOLLOWING SEASON

Series	1937	1938	1939	1940	Average calculated on sum of the totals in respective years
A	46	60	78	73	64
B	52	52	66	56	56
C	45	52	73	73	61
D	31	30	58	52	42
E	10	18	35	38	26

Sign. diff. (P .05) of annual treatment totals = 24%

" " " of treatment average = 8%

There was no significant difference in the percentage of undiseased bushes which became infected in the course of the respective seasons.

A number of important conclusions may be drawn from the above observations.

In the course of the period under observation the percentage of bushes, uninfected in the previous year, which became infected was almost constant with no significant difference between the various series of plots. This percentage was about 23. We must assume that 23% of all bushes would be liable to new infection each year. The Burgundy mixture apparently cured about 50% of the infected bushes while the Lime sulphur treatment cured 30% in normal years. In 1939 and 1940 there was a high natural recovery - no less than 35%. This must be considered unusual as it so far exceeded the natural increase in the percentage of bushes newly infected that under such conditions the Black rot would have disappeared within a few years without any treatment at all. We may assume that the natural recovery is about the average of 1937 and 1938 observations on the untreated plots. That is about 15%.

This would leave a net increase of 8% each year on untreated areas. Once control has been established on a particular section it would still be necessary to deal with new infections which would be about 25% of the total number of bushes. It is of course possible that this figure would be reduced to a considerable extent when all sections of tea in the vicinity are under systematic treatment but we have no proof of this.

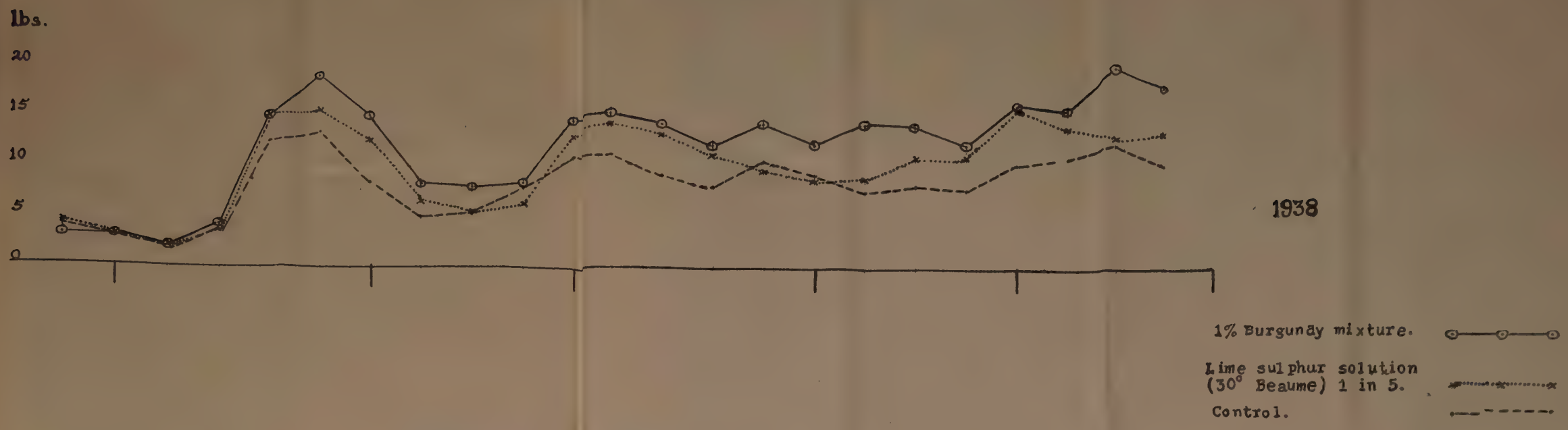
It will be noted that the total percentage of infected bushes on those plots treated with Burgundy mixture has approached the figure for natural reinfection, as shown by the average percentage of healthy bushes which became infected, for the last two years (1939 and 1940). It may be assumed therefore that control has been established by the treatment in 1937 and 1938. In the plots treated with Lime sulphur the reduction has been great but the total number of bushes infected has not yet reached the level of natural reinfection. It is however probable that in time it will do so. It should be noted in this connection that the Lime sulphur solution applied was much more concentrated than that usually applied in the growing season.

The very high natural recovery during 1938-39 and 1939-40 may in part be associated with careful cleaning out in successive years but most of it is probably due to climate and in 1939-40 at any rate the abnormally dry cold weather may have had a lot to do with it. All our observations on Black rot treatment show a remarkable natural reduction in Black rot in 1940.

The average increase in yield associated with the treatment of Black rot was about 10% or, on the area concerned, little over one maund of dry tea per acre In this respect Lime sulphur solution was almost as good as Burgundy mixture and 1% Burgundy mixture was as good as 4% and rosin adhesive was not found to increase the efficiency of these mixtures in relation to yield. The number of bushes sprayed per gallon of spray fluid is given below.

Series	1937	1938	1939	1940
A	11.8	9.1	5.3	10.6
B	11.9	7.7	6.4	10.7
C	10.7	8.3	5.6	9.0
D	17.3	12.3	8.4	10.6
E	0.0	0.0	0.0	0.0

Weekly yield (in lbs.) of Black rot affected plots at Boro Jalinga T.E., Cachar



Weekly yield (in lbs.) of Black rot affected plots at Borhat T.E., Upper Assam.

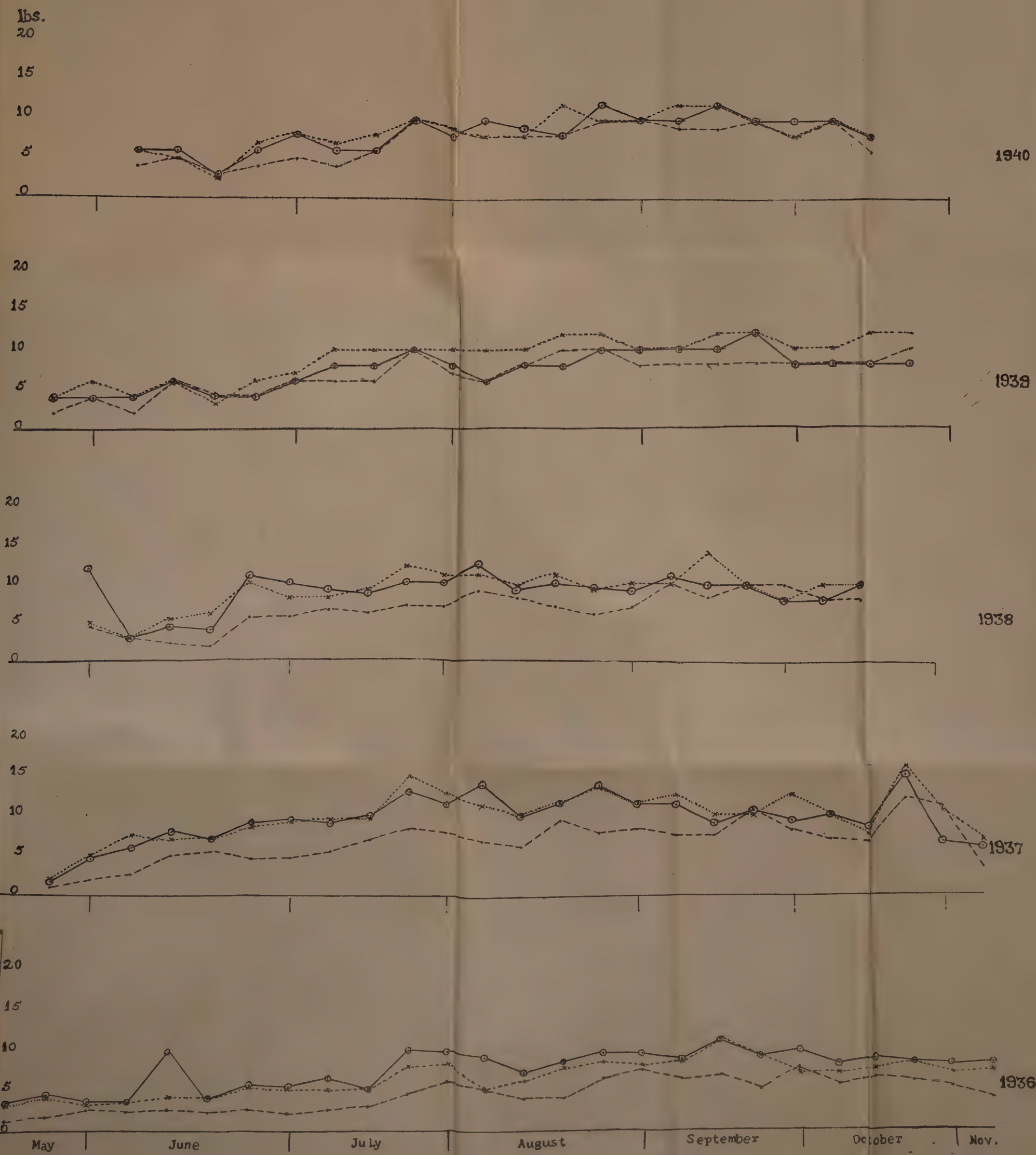


PLATE 7—Weekly yields of Sprayed and unsprayed plots affected by Black rot.

The number of bushes sprayed does not bear a close relationship to the number of individual bushes attacked as some of the latter required to be sprayed more than once before the disease failed to reappear after treatment. To attain control by Burgundy mixture about 50 gallons per year was required on the 500 bushes concerned. This would mean about 250 gallons per acre. Thus with 1% mixture 25 lbs. of copper sulphate and 12 lbs. of soda ash would be required per acre for the preparation of the fluid without rosin adhesive, (which appears to be unnecessary). With Lime sulphur about 375 gallons would be required per acre. This would require 75 gallons of concentrate (30° Beaume) at the strength used in the experiment. The Lime sulphur at this concentration would obviously come out much more expensive than the 1% Burgundy mixture.

The effect of the disease on the yield of leaf is also shown by the depressions in the curves that occur during the period of heavy infection. (Pl. 7).

MYCOLOGICAL NOTES

Corticium invisum. Petch :—

Basidia—short, club-shaped, with 4 short sterigmata, about 12·5 X 9.5 microns.

Spores—Ob-ovoid, slightly curved at the base end, continuous, hyaline, smooth, variable in size, 7.6—10.9 x 5—6.2 microns.

Corticium theae, Bernard :—

Basidia—short, club-shaped, with 2—4 sterigmata, about 11.7—16.5 x 8.2—9.5 microns average 14.5 x 9.2 microns.

Sterigmata—Attenuate, about 3.5—7.2 microns long and about 1.7 microns broad at the base.

Spores—Elliptic, slightly curved and apiculate at the base end, continuous, hyaline, smooth, about 8.2—12.9 x 3.5—7 microns average 10.2 x 5 microns.

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